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PULPWOODING WITH LESS MANPOWER

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The one-man chain saw--boon to efficient pulpwooding.

PULPWOODING WITH LESS MANPOWER

Sam Guttenberg and Joe D. Perry
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In some twenty eventful years since 1935 southern pulpwood production has leaped from 2 million cords annually to 20 million--and further increases are imminent. During this period, the rural population--the primary source of pulpwood labor--decreased markedly, with additional shrinkage likely. Today, the pulp and paper industry is aware that the pressing problem is to make more pulpwood with less manpower. Further, costs must be kept reasonable, for over the years the outlay for wood has been making up more and more of the total cost of producing pulp.

Traditional pulpwood suppliers, 2 or 3 men equipped with a saw and light truck and working part-time, still produce most of the pulpwood, but professional yearlong operators are bringing in an increasing proportion. The paper industry is rapidly approaching the point where it will have to depend heavily on professional wood cutters--that is, producers who can provide a combination of timber and machinery that will assure earnings sufficient to hold young and vigorous men in pulpwooding throughout the year.

This paper evaluates the labor requirements of several systems of pulpwooding in various timber types. Three methods of loading and hauling pine bolts were compared in the flatwoods of Arkansas. Another pine operation, and also a pine-gum harvest, was observed in the rolling hills of central Mississippi. Finally, a crew was timed while cutting hardwoods in the bottoms of the Pearl River, also in Mississippi.

Recently, large numbers of mechanized woodyards have appeared in the South. Some cordage from the Mississippi operations was trucked to such a yard, to measure the degree to which yard equipment speeded wood handling.

STUDY METHOD

The approach in this study was essentially that advocated by Hasel and Downs, among others (6, 8). That is, variations in output of men and machines were related to the characteristics of the timber being cut. Differences in man- and machine-hours required to produce pulpwood were tested for association with the volume and the number of trees and bolts cut per acre, mean tree size, dispersion around mean tree size, and other stand factors of the kind readily derived from the data normally collected when timber is marked for harvest.

In each of the various tests the plan was to harvest a constant volume of pulpwood from each plot, but to vary the plot acreage to provide a range of cutting conditions. As the trees were cut, each one was calipered to determine its d. b. h. to the nearest inch, and the number of its bolts was counted. The commonplace 5-foot bolt was standard throughout the study. Commercial pulpwood scale established cut volume for each plot. These data, together with surveyed plot acreages, provided the basis for analyzing productivity in terms of the structure of the cut stand.

Felling, bucking, and limbing combined were timed as a work unit. The other four elements--each timed separately--were bunching, loading, hauling, and unloading. Man- as well as machine-hours were noted. No distinction was drawn between effective and noneffective work time: visits to the water barrel, filing saws, fueling machines, and the like were counted as normal to the job.

Productivity per man-hour is stressed throughout this report because the pulpwooder's goal is usually a certain number of truckloads or cords per week. The work day tends to be short in good timber and long in poor. Therefore man-hour data are somewhat more meaningful than man-day output unless the latter is averaged over more work days than is usual in time studies.

The applicability of cost data to conditions other than those specifically investigated is never known. The procedure followed in this study is recommended for those willing to make their own analyses. Beyond that, timber growers, large-volume pulpwood producers, and processors can use the data with due regard to how their own timber, crew organization, and equipment differ from those described herein.

FLATWOODS PINE

Thirty-two plots yielding about 220 cords of pine were installed in flatwoods shortleaf-loblolly pine hardwoods near Camden, Arkansas.

This level stretch of country is much like the longleaf-slash pine belt of the lower Coastal Plain, except that the understory is brushier. The timber was marked to simulate partial cutting, except that a deliberate effort was made to include some trees larger than those usually removed in present-day pulpwood thinnings. The plots were clustered along both sides of a gravelled all-weather road. The average hauling distance to the millyard was 24 miles, nearly all paved.

The purpose was to compare traditional stump loading of single-axled "bobtail" trucks with two alternative pallet systems,one involving a tandem-axled truck carrying 2 pallets, and one using a trailer hauling 5 pallets. Ten plots were assigned to stump loading,10 to the palletized tandem, and 12 to the trailer. Each set of plots represented about the same range of cutting conditions. The timber was harvested during August and September 1956.

The producer's men worked in felling, loading,or hauling teams, without shifting back and forth between functions. The men were paid by the unit of output--the cutters by the cord, the loaders by the pallet, and the drivers by the truckload. Payment by unit of output, in one form or another, is common to the pulp industry, for it is perhaps the easiest way of coping with the problem of supervision. Especially where scattered trees are being cut in brushy areas and rolling hills, men paid by the hour are unlikely to be as productive as those paid piece rates.

Felling, bucking, and limbing.--The alternative pulpwooding systems differed only in the way bolts were handled after they had been made. Consequently, felling, bucking, and limbing was studied independently of system. Bolts on all plots were produced by the same 4-man team, which consisted of a faller, a bucker, and two limbers. The faller used a Model 47 McCulloch chain saw with a bar attachment and the bucker the same make of saw with a bow. Special care of saws was sacrificed for speed in cutting. A plentiful supply of parts was kept at hand, as spark plugs lasted a week or less and chains about 400 cords. The sawyers preferred the heavier equipment because it had less down time. Field repairs were made in a matter of minutes and saw stoppage was trivial.

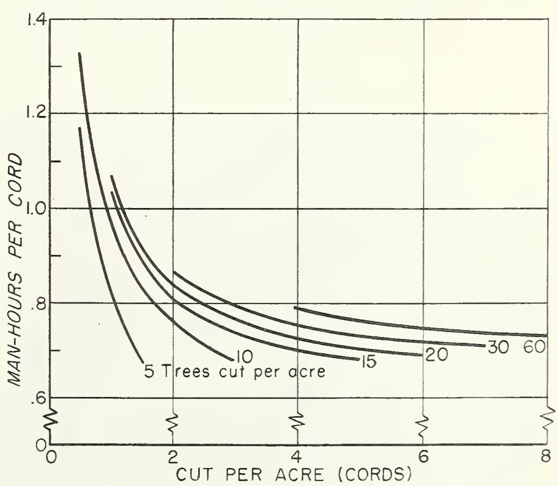


Figure 1.--Man-hours per cord for felling, limbing, and bucking flatwoods pine.

Figure 1 presents the data on felling, bucking, and limbing. It will be seen that the number of man-hours required to produce a cord of wood decreased as cut per acre increased. Average tree diameter, as indicated by the number of trees required to make up any given cut per acre, was also influential. These findings agree with those of other studies. Cuno and Reynolds, observing partial cuts between 1936 and 1945, found that handsaw teams took 4 man-hours to produce a cord of bolts (5, 9, 10). Under roughly comparable conditions in the present study, one-man chain saws reduced labor needs to less than 1 man-hour per cord. Power saws have been a main factor in making it possible to cut more pulpwood with less manpower.

Figure 1 can also be used to estimate saw use. Because only 2 of the 4 men in the crews had saws, and because the sawyers did not trade jobs with the limbers, halving the man-hours provides an estimate of saw-hours. For example, a cut of 15 trees per acre, containing 2 cords, would require 0.8 man-hour and 0.4 saw-hour per cord.

The source of figure 1 is the formula:

$$\hat{Y} = 0.70 + \frac{0.45}{C} - \frac{1.64}{N}$$

where: C = cut per acre in standard cords
N = number of trees cut per acre.
The multiple correlation coefficient (R) is 0.746.

STUMP LOADING

Two-ton bobtail trucks, carrying an average load of 3 cords, were used to haul the bolts to the millyard. The trucks were not driven from stump to stump, as the system's name implies; rather, bolts were piled near swamped roadways for loading.

The loading teams consisted of 3 men, one of whom was the truck driver. While the truck was on the plot, the driver was out of his cab two-thirds to three-quarters of the time, usually working on top of the load; for convenience, all of his time is counted in

loading. While the truck was on the road, the other two loaders swamped roadways and located and piled bolts.

The productivity data are summarized in figure 2. Cut per acre affected productivity because it influenced the time required to find bolts, the distance they had to be carried or tossed, and the amount of swamping. For these reasons, loading time decreased sharply as cut per acre rose from 0.5 to 2 cords. Beyond a 2-cord cut, swamping and related tasks were only slightly affected.

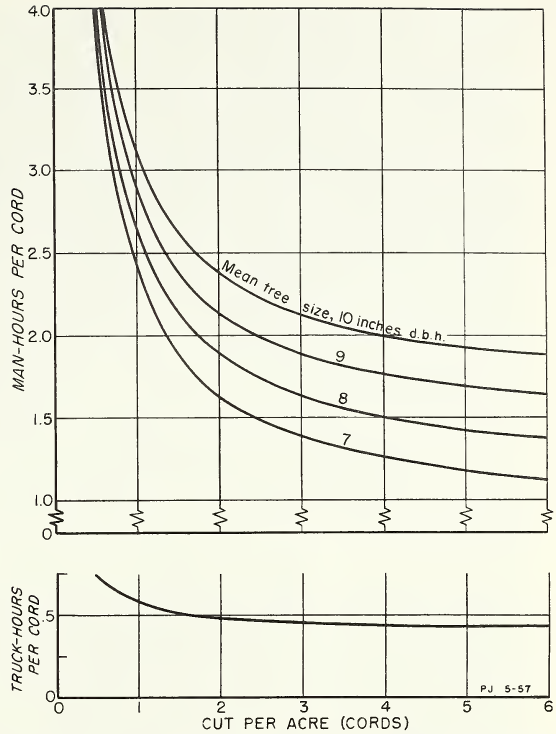


Figure 2.--Man-hours and truck-hours for stump loading.

As mean tree size (diameter at breast height) declined and bolt diameter declined with it, more cords per man-hour were loaded. The reason was chiefly that cords consisting of large bolts weigh more than those made up of small bolts (11). That is, the solid volume of wood and hence the weight per rough cord increase with average bolt size. Too, carrying heavy bolts to the truck probably burned up human energy disproportionately.

The curves in figure 2 were computed from the formula:

$$\hat{Y} = \frac{1.52}{C} + 0.25\,\frac{SD}{N} - 0.86$$

$$R = 0.798$$

where: C = cut per acre in standard cords

$\frac{SD}{N}$ = Sum of the tree diameters (at breast height) per acre divided by the number of trees.

Truck-hours in loading also varied with cut per acre. The truck-hour curve at the bottom of figure 2 takes in all time between the truck's arrival on the plot and its departure to the millyard--standby time plus travel between piles of bolts.

The curve is based on the equation:

$$\hat{Y} = 0.40 + 0.17 \div \text{cords per acre}$$
$$r = 0.772$$

The bobtails carried their 3 cords at an average round-trip speed of 31.3 m.p.h., or 0.021 truck- and man-hour per cord per round-trip mile. At the millyard trucks were unloaded mechanically. Delay time and spotting the trucks for scaling and unloading required 0.14 truck- and man-hour per cord.

PALLET SYSTEMS

Shortly after the close of World War II, pallets were introduced to the southern pulpwood industry. At first they were used primarily for logging in wet weather, when stump loading is infeasible. Nowadays they are becoming increasingly popular because they minimize labor required in loading and hence make the job more attractive. Too, they promise to increase wood production by farmers and other part-time workers, for they eliminate the need for truck ownership and bolt delivery. That is, empty pallets can be spotted at the farmstead and picked up whenever filled.

Pallet capacity varies with the length of the truck or trailer bed and with other factors. High-grade steel pipe (salvaged from the oil fields) or double-strength iron pipe is used for the frames, and shaped steel plates are welded to the bottom members to reduce drag friction. The tandem truck's pallets averaged 2 cords' working capacity, the trailer's pallets were smaller; they held 1.4 cords. Power take-offs and winches were used to make the truck and trailer self-loading. The tandem used man-handled steel skids and the trailer a permanently attached bumper bar in loading, (figs. 3 and 4).

The palletized tandem.--Unlike the bobtail truck, the tandem truck was spared the wear and tear of driving through the woods from bolt pile to bolt pile. It entered the woods only at convenient points, to drop empty pallets and load full ones. The driver loaded and unloaded pallets with nominal help from one of the bolt handlers.

The pallet loading team included 4 men--the driver of a D-4 Caterpillar tractor, a bolt spotter, and two loaders. The tractor was used to bunch rather than skid. It hooked on to an empty pallet, towed it to nearby bolts located by the spotter, and then returned the filled pallet to the truck's loading point. Where bolts were plentiful or large, all 4 team members helped to get them on the pallet (fig. 5).

Figure 3.--Spilling empty pallets and winching full ones onto the tandem.

Figure 4.--Loading the palletized trailer.

Figure 5.--Pallet loading.

Enough pallets were available so that truck loads were readied about as fast as the truck completed round trips to the millyard. Between 2 and 3 times the number of pallets carried by the hauling unit were needed for efficient operation.

As one would expect, it took fewer man-hours to load bolts on pallets than to stump-load them on bobtails. Within this general advantage, wood output varied as it did with stump loading (fig. 2). That is, labor per cord decreased rapidly as cut per acre rose from 0.5 to 2 cords. Small bolts loaded faster than large, mainly because of weight differences per cord, as explained previously.

Much of the saving of man-hours by pallet loading over stump loading can be attributed to the fact that bolts must be lifted about 3 feet higher to the truck than to the pallet. Since the average cord weighs about 5,000 pounds, it may be calculated that stump loading requires 15,000 foot-pounds more human effort per cord than pallet loading. Too, many bolts that require two men to load directly on a truck can be up-ended onto a pallet by one man.

The difference between stump and pallet loading can be illustrated by an example. For instance, if timber averaging 8 inches d.b.h. and 2 cords per acre is stump-loaded, 1.9 man-hours per cord is required (fig. 2). Pallet-loading the same timber takes only 1.3 man-hours per cord (fig. 6).

Figure 6 applies to tractor use also because tractor-hours for all variables are 1/4 of man-hours.

Figure 6 was derived from the formula:

$$\hat{Y} = 0.68 + \frac{0.39}{C} + 0.06\,\frac{SD}{N}.$$

$$R = 0.871$$

where: C = cut per acre in standard cords

$\frac{SD}{N}$ = Sum of tree diameters per acre divided by the number of trees.

Tractor driving time as well as the nominal assistance provided the truck driver in loading pallets is included in loading man-hours.

Loading the pallets on the tandem required 0.08 truck- and man-hour per cord. The tandem carried 4 cords at an average round-trip speed of 27.9 m.p.h., or 0.018 truck- and man-hour per cord per round-trip mile. At the millyard 0.14 truck- and man-hour per cord was needed to scale and unload the bolts.

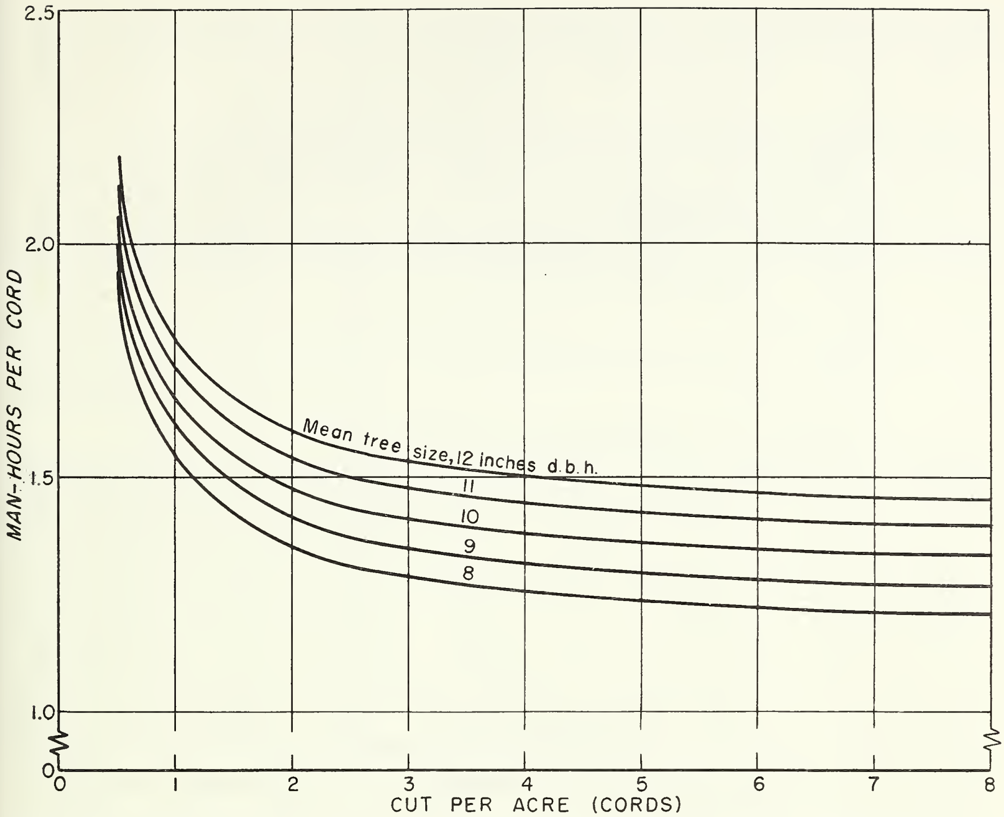


Figure 6.--Man-hours per cord for loading 2-cord pallets (tandem).

The palletized trailer.--The palletized trailer and tandem are similar in that they are self-loading. The main difference lies in the degree of off-the-road maneuverability, in which the tandem is superior. Even though the trailer's pallets are smaller, the length of the unit and the loaded weight preclude off-the-road hauling. On tracts lacking sufficient gravel roads or their load-bearing equivalent, pallets would have to be skidded considerable distances to the trailer. Under the same conditions, the tandem could be driven onto the tract. This difference between the two systems did not affect the present study, however, for all plots were adjacent to a gravel road.

The identical loading crew and tractor studied in the tandem operation was used on the trailer plots.

As a comparison of figures 6 and 7 shows, the small pallets were more efficient than large ones for timber of the usual pulpwood sizes.

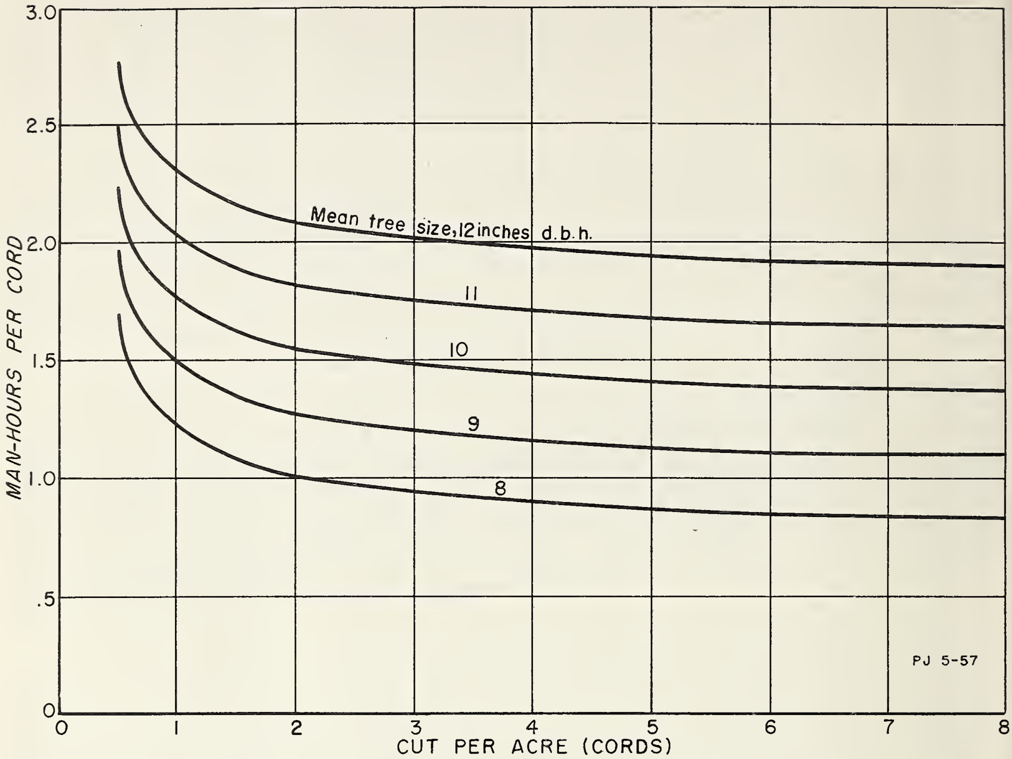


Figure 7.--Man-hours per cord for loading 1.4-cord pallets (trailer).

For timber averaging 10 inches and larger, the tandem's 2-cord pallets proved more efficient than the trailer's 1.4-cord pallets. The difference may arise partly because the trailer system requires the tractor to couple, pull, and uncouple more pallets per cord. The tractor must also cover a greater area per cord to gather in a trailer load than a truckload--and the truck is a faster prime mover than the tractor. The differences notwithstanding, both pallet systems required fewer man-hours than did stump loading.

The pallet loading curves in figure 7 were computed from the formula:

$$\hat{Y} = 0.27 \frac{SD}{N} + \frac{0.45}{C} - 1.38$$

$$R = 0.849$$

where: $\frac{SD}{N}$ = Sum of the tree diameters per acre divided by the number of trees

C = cut per acre in standard cords.

As with the tandem system, tractor-hours are 1/4 of man-hours. The time used in driving the tractor and helping the truck driver load the trailer is included in pallet loading.

Loading the pallets on the trailer required 0.06 truck- and man-hour per cord. The trailer carried 7 cords at an average round-trip speed of 26.7 m.p.h., or 0.011 tractor- and trailer-hour per cord per round-trip mile. At the millyard 0.07 machine- and man-hour per cord were needed to scale and unload the pulpwood.

THE ALTERNATIVES COMPARED

A specific example will serve to compare stump loading with the pallet systems. Assume that each method is used to log tracts that have been marked to yield 20 trees to the acre, averaging 8 inches in d.b.h. and containing 2 cords. The timber is 20 miles from the nearest mechanized mill- or woodyard. Hourly machine rates, exclusive of operator's wages, are estimated at $3.00 for bobtails, $5.00 for Caterpillar D-4's, $4.00 for palletized tandems, $6.00 for the palletized trailer system, and $1.50 for the chain saws. These costs are for illustrative purposes and are not necessarily typical. Even for standard items, costs vary from operator to operator because of differences in maintenance, method of obtaining supplies, estimating depreciation, and the like. Each operator must rely on his own experience and records in setting machine rates. For convenience, all labor is estimated at $1.00 per hour; Social Security and Workmen's Compensation fees are omitted from the example, but must be recognized where appropriate.

Stump Loading (fig. 2)

		Dollars per cord
LOADING:		
1.9 man-hours	@ $1.00	1.90
.5 truck-hour	@ $3.00	1.50
HAULING:		
20 miles x .021 hour = .42		
Unloading at mill = .14		
.56 truck-hour	@ $3.00	1.68
.56 man-hour	@ $1.00	.56
		5.64

Palletized Tandem (fig. 6)

		Dollars per cord
LOADING PALLETS:		
1.3 man-hours	@ $1.00	1.30
.3 tractor-hour	@ $5.00	1.50
HAULING:		
Loading truck = .08		
20 miles x .018 hour = .36		
Unloading at mill = .14		
.58 truck-hour	@ $4.00	2.32
.58 man-hour	@ $1.00	.58
		5.70

Palletized Trailer (fig. 7)

		Dollars per cord
LOADING PALLETS:		
1.0 man-hour	@ $1.00	1.00
.25 tractor-hour	@ $5.00	1.25
HAULING:		
Loading trailer = .06		
20 miles x .011 hour = .22		
Unloading at mill = .07		
.35 truck-trailer hour	@ $6.00	2.10
.35 man-hour	@ $1.00	.35
		4.70

The cost of felling and bucking the timber (fig. 1) is the same for each method, about $1.48 per cord (comprised of 85 cents for 0.85 man-hour plus 63 cents for 0.42 saw-hour). Thus, total production cost varied from $6.18 to $7.28 per cord. As the example shows, the palletized trailer was the best by a small margin. In general, for cuts below 3 cords per acre either pallet system saves enough man-hour expense to more than pay machine costs.

At cuts of 1 cord per acre, but with all other assumptions as before, costs would be $8.49 per cord for stump loading, $8.11 for the tandem, and $6.90 for the trailer.

A saving of 0.8 man-hour of loading labor is needed to offset the machine costs of pallet systems. A glance at figures 2, 6, and 7 makes plain that at cuts beyond 3 cords per acre such savings over stump loading were not achieved. Nevertheless, the cost differences are so small that slight gains in wage rates relative to machine costs will eliminate stump loading as an alternative. In the foregoing examples, the addition of Social Security and Workmen's Compensation fees would have made stump loading a much poorer alternative.

Dollar comparisons aside, pallets may be the solution for producers who find it difficult to recruit labor for the arduous job of stump loading.

ROLLING HILLS PINE

Pulpwood producers recognize that their operations have to be fitted to terrain and timber type. In the hills, stump loading is infeasible and the professionals use light tractors to bunch tree boles.

To evaluate a hill operation, 20 pine plots were installed in shortleaf-loblolly pine-hardwood stands near Carthage, Mississippi. Wood was hauled on two tandem-axled trucks carrying 4.5 cords per load. Bolts from 10 of the plots were delivered to a public rail siding, while those from the other plots were hauled to a mechanized woodyard at Canton, Mississippi.

The plots, which were marked for a partial cutting, yielded a total of 335 cords. The timber was harvested during September 1955. As in Arkansas, the production was timed by function.

The crew varied from 7 to 11 men, and were paid by the cord for each day's output; each man received the same rate of pay. The men shifted freely between all the various activities of felling, bunching,

Figure 8.--The tandem-axled trucks averaged 4.5 cords per load.

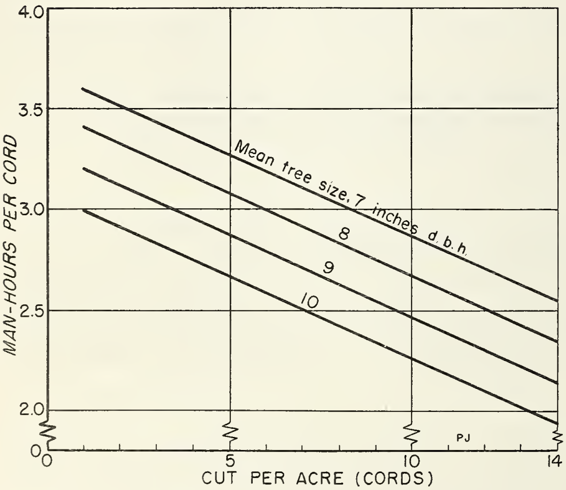
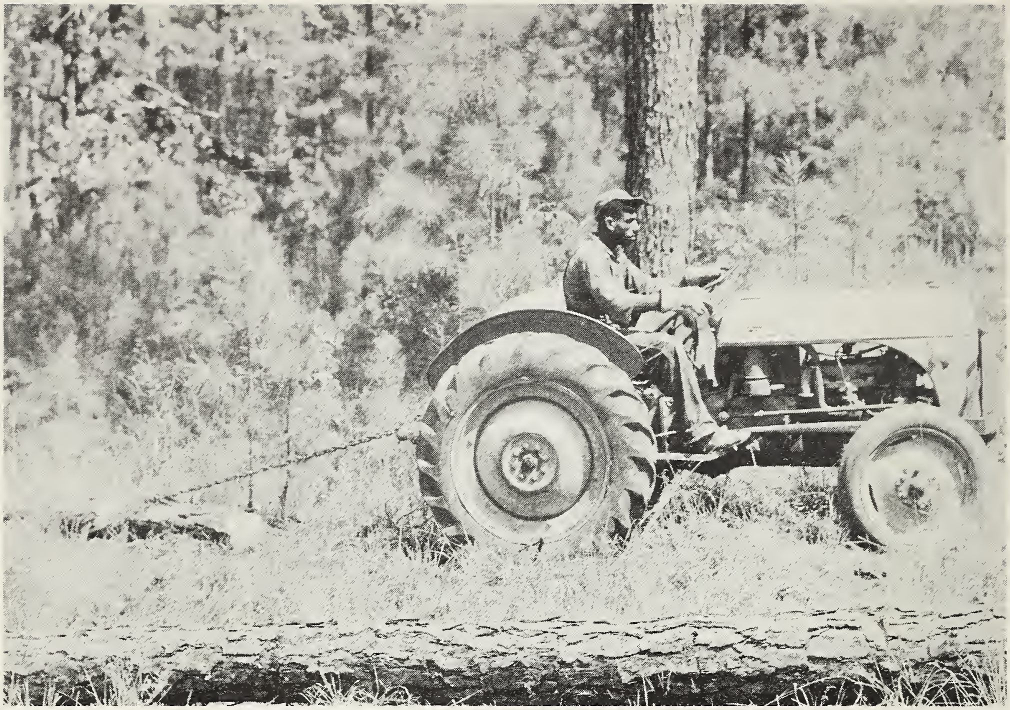


Figure 9.--Man-hours per cord for felling, limbing, and bucking hill pine.

bucking, loading, and hauling. The emphasis was on team work to get out the cordage to make the day. Because shirking reduced the wages of all, the men saw to it that each one did **his share**--in effect, supervised themselves. The producer worked as part of the team, chiefly to see that his equipment was not mistreated.

Felling, limbing, bunching, and bucking.--Homelite 530 bow-type chain saws with safety guards were used exclusively for felling and bucking. Though these are rated as one-man saws, the producer preferred to use 2 men per saw. The felled



trees were limbed and topped and then snaked to convenient loading points with a light Ford tractor. They were bucked at the loading point. Unusually heavy or long trees were cut in two before being bunched, but care was taken to assure that the butt section would buck into bolts without waste.

Man-hours for felling, limbing, and bucking are charted in figure 9. As in the flatwoods, man-hour input per cord decreased with increases in tree size and cut per acre. But while the pattern was the same, 3 times as many man-hours per cord were required to produce bolts in the hills as in the flatwoods. The difference may be attributed to variations in the terrain and undergrowth, attitude toward equipment, and the fact that 2 men were used per saw. Care given the equipment was reflected in the fact that saw costs averaged about 50 cents per cord, as against 63 cents in the flatwoods operation.

Time required for bunching decreased with increasing cut per acre. Bunching time increased as number of trees per cord declined, because the larger trees were in the hollows and the loading points were mainly on the ridge tops. These influences were strongest for cuts be-

low 5 cords per acre. Because bunching was a 1-man operation, figure 10 can be read directly for both man- and tractor-hours. Some factors not measured in this study influence bunching. Two are of paramount importance; the relative abundance of feasible loading points, and variations in grade. Campbell found that slopes impair the efficiency of small tractors (4).

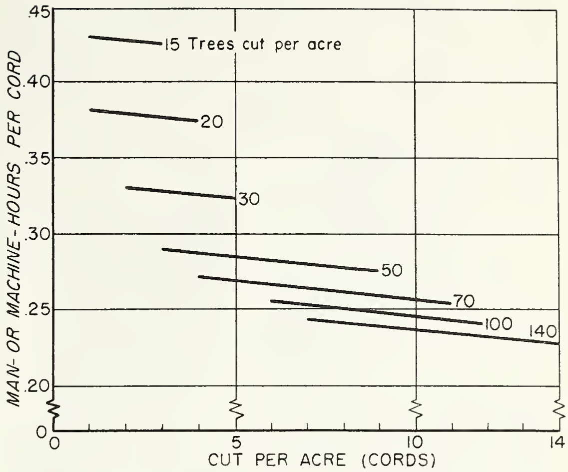


Figure 10.--Man- or machine-hours per cord for bunching hill pine.

The formula for felling, bucking, and limbing is:

$$\hat{Y} = 5.15 - 0.08\ C - 0.21\ \frac{SD}{N}$$

$$R = 0.888$$

where: C = cut per acre in standard cords

$\frac{SD}{N}$ = Sum of the tree diameters per acre divided by the number of trees.

For bunching, the formula is:

$$\hat{Y} = 0.24 - 0.0024\ C + \frac{2.9}{N}$$

$$R = 0.709$$

where: C = Cut per acre in standard cords

N = Number of trees cut per acre.

LOADING AND HAULING

From plot to plot, the time required to load the trucks varied from 1.5 to 2.8 man-hours per cord. The average for all plots was 2 man-hours. The variation in loading time between plots was not significantly related to any of the measured timber characteristics. One would suspect an association between loading man-hours and sticks per cord, but none was found despite a range of 44 to 75 (average 55) bolts per cord. Apparently loading from windrows minimizes productivity differences attributable to bolt size.

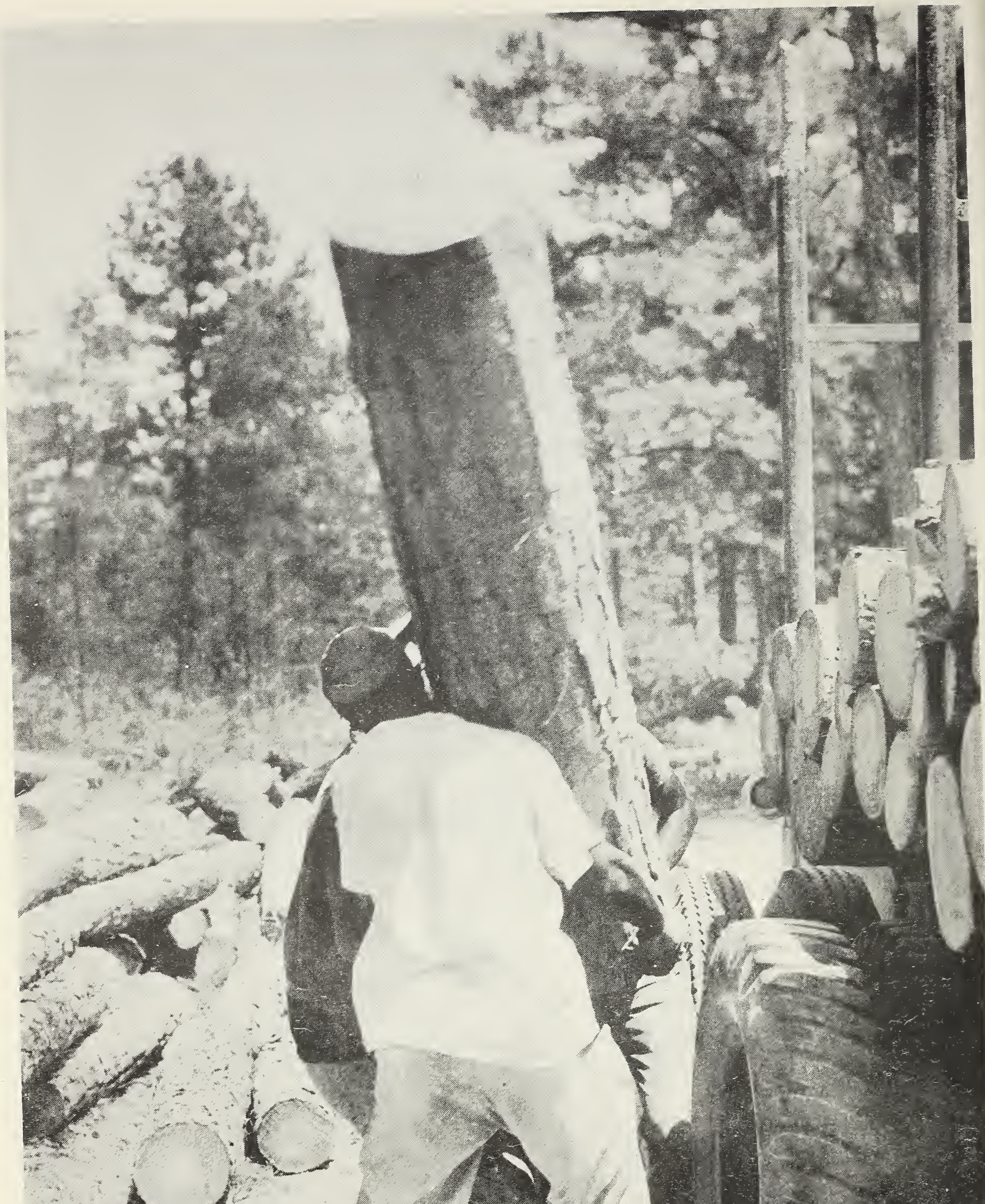


Figure 11.--Loading from windrows makes it easier to handle big bolts.

The trucks averaged a round-trip speed of 34.7 m.p.h., or 0.013 truck-hour per cord per round-trip mile on graded gravel and paved roads; and 10.5 m.p.h., or 0.042 truck-hour per cord per round-trip mile on dirt and woods roads combined. These speeds are considerably better than the 25 m.p.h. and about 7 m.p.h. reported in earlier studies for 1-1/2-ton trucks on comparable roads (3, 9). Standby time in loading was one-third truck-hour per cord. Unloading consumed 0.1 truck-hour per cord at the mechanized yard and 0.28 truck-hour at the public siding.

As with loading, differences in unloading time were not significantly associated with variations in average bolt size per cord. Hand transfer of bolts to railcars took 0.59 man-hour per cord as against 0.1 man-hour (standby time of the truckdriver) at the woodyard. The data for hand unloading appeared essentially the same as those reported in earlier studies (3, 9, 10).

COST SUMMARY

Production costs in the hills may be compared with those in the flatwoods by recalling the imaginary tract on which 20 trees, averaging 8 inches d.b.h. and containing 2 cords, have been marked for cutting on each acre. Labor is again $1 per hour, and the haul is 20 miles to a mechanized yard. Machine rates are different, being $3.50 per hour for the tandems and $1 for the Ford tractor.

			Dollars per cord
FELLING, BUCKING, AND LIMBING (fig. 9):			
3.3 man-hours		@ $1.00	3.30
Saw use			.50
BUNCHING (fig. 10):			
.4 tractor-hour		@ $1.00	.40
.4 man-hour		@ $1.00	.40
LOADING:			
2 man-hours		@ $1.00	2.00
HAULING:			
Loading standby	= .33		
20 miles x .013	= .26		
Unloading standby	= .10		
	.69 truck-hour	@ $3.50	2.42
	.36 man-hour	@ $1.00	.36
			9.38

In effect, it appears to take over $2 more per cord to produce pulpwood in the hills than in the flatwoods. The biggest item of difference is in felling and bucking. Variations in crew organization, equipment, and men account for some of the extra cost, but much is attributable to the more difficult terrain.

MIXED PINE-GUM

The hardwood pulpmills adjacent to the Delta rely chiefly on bottomland gums for their wood supply, but purchase gum bolts from the uplands as well. "Hill gum" is especially prized when high water makes the bottoms inoperable. In the uplands, gum usually occurs as occasional trees in the minor hollows. To keep logging costs reasonable the producer strives to sweeten his cut with pine. This practice is possible because the woodyard routes pine bolts to kraft mills and gum to hardwood plants.

Mixed pine-gum pulpwooding was observed near Canton, Mississippi. Twenty plots that yielded 205 cords were cut during May and June of 1956. The mixtures ranged from 26 to 78 percent gum among the plots, averaging about 50.

Crew, producer, and operating methods were identical with those in the study at Carthage, except that hauling was done with two bobtail trucks and that an Oliver O C-3, a light track-type machine, was used for bunching.

Felling, limbing, bunching, and bucking.--Because the gums are found in dense brush at the bottoms of hollows, they take an extra effort to prepare for felling. Accordingly, the data showed that man-hour requirements per cord rose with increases in the proportion of gum in the cut (fig. 12). Beyond this, productivity improved as cut per acre and mean tree size increased.

The trees were limbed and topped where they fell, and then bunched at convenient points for bucking and loading. Because the gums were farther from the loading points than pines, there was a slight but significant association between bunching time and the percent of gum in the cut. For practical purposes, however, an average of 0.38 man- and tractor-hour per cord was needed for bunching.

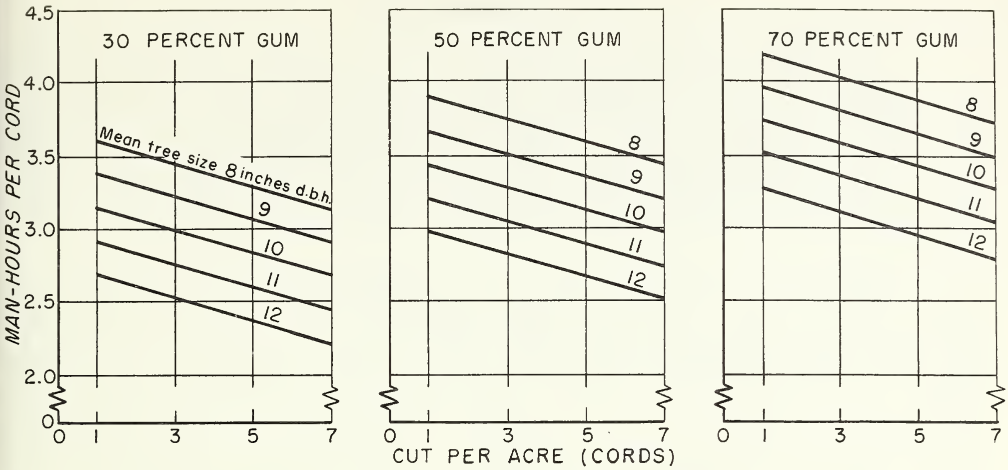


Figure 12.--Man-hours per cord for felling, limbing, and bucking pine and upland gum.

Figure 12 derives from the formula:

$$\hat{Y} = 5.08 - 0.08C + 1.49G - 0.23\frac{SD}{N}$$

$$R = 0.774$$

where: C = Cut per acre in standard cords
G = Percent of gum in the cut
$\frac{SD}{N}$ = Sum of the tree diameters per acre divided by the number of trees.

LOADING AND HAULING

The 2-ton bobtail trucks averaged about 3 cords per trip. Loading the bolts took 1.5 to 2.6 man-hours, and averaged 2 man-hours. As with pure pine, the variation in loading time between plots was not significantly associated with any of the measured timber characteristics. The number of bolts per cord ranged from 29 to 64, averaging 47. Although pines and gums were felled in order of occurrence, the bolts were not mixed in loading.

The trucks averaged 20 m.p.h. round-trip speed, or 0.033 truck-hour per cord per round-trip mile over graded gravel and paved roads. Standby time for loading in the woods was 0.49 truck-hour per cord. At the woodyard 0.1 man- and truck-hour per cord was utilized to spot the trucks for scaling and transfer the bolts by machine to rail cars.

BOTTOMLAND GUM

During October and November 1955, a bottomland operation was studied. Crew, equipment, and organization were the same as in the mixed pine-gum trial. Twenty plots that yielded about 170 cords were established in the Pearl River bottom near Carthage, Mississippi. Bolts from half the plots were delivered to a public rail siding, while the rest went to the mechanized yard at Canton.

The stand contained some cherrybark, cow, and other oaks, blue beech, soft maple, and white elm, but most of the volume was in gum; and only gums--mainly sweet and tupelo gum, but with a few blackgums--were marked for cutting. Many of the marked trees had rotten butts, the consequence of fire damage. The larger and older trees, left over from the virgin stand, often had top rot as well. In general, the timber cut was typical of that likely to be offered for pulpwood production in southern bottomland forests being placed under management.

Felling, limbing, bunching, and bucking.--For several reasons, productivity per man-hour spent in felling, limbing, and bucking was markedly less than in pine. Mills will not accept bolts with rot, holes, or excessive sweep--defects more common to hardwood than pine. Jump-butting was frequent, and often several bucking cuts were made before clear wood was reached. In the tops, crooks, holes, and rot had to be blocked out. The power saws enabled the crews to make bolts that handsaw men would have passed by.

The gums also hung up in felling with greater frequency than pines do, and thus slowed down bunching as well as felling.

As figure 13 shows, cordwood output per man-hour increased rather rapidly until cut per acre reached 6 cords and then stayed about the same. Productivity declined with larger tree sizes (fewer trees per acre) because the larger and older trees were more defective than the smaller ones. In relatively undamaged gums from managed stands productivity would probably increase with tree size, as it did on the pine and the pine-gum plots.

In bunching, man- and machine-hours were not significantly associated with any of the measured timber characteristics. In effect, the average of 0.4 man- and machine-hour per cord is the best estimate of bunching regardless of the structure of the cut stand.

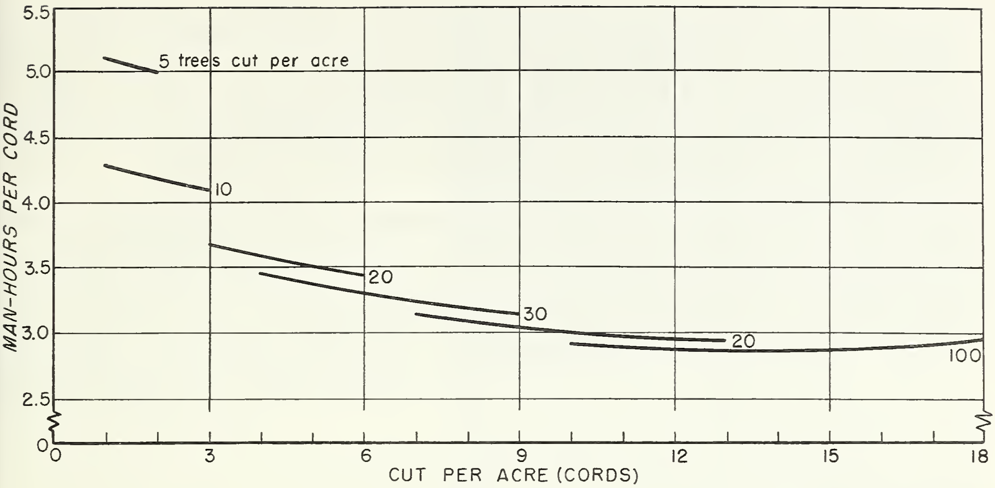


Figure 13.--Man-hours per cord for felling, limbing, and bucking bottom-land gum.

The formula for figure 13 is:

$$\hat{Y} = 3.58 - 0.119C + 0.00444C^2 + \frac{8.26}{N}$$

$$R = 0.745$$

where: C = Cut per acre in standard cords
N = Number of trees cut per acre.

LOADING AND HAULING

While the trucks averaged 3-cord loads in the hills, the rough off-the-road conditions in the bottoms restricted their working capacity to 2.3 cords. From plot to plot loading time ranged from 0.9 to 2.2 man-hours per cord, and averaged 1.3. The variation was not associated with the measured variables. The number of bolts per cord ranged from 32 to 65, averaging 50.

The difference between the 2 man-hours per cord for loading pine and pine-gum and the 1.3 man-hours for gum is primarily due to two factors. First, the 3-cord pine-gum loads required raising bolts to a greater height, at a greater man-hour effort per cord. Second, though green pine and gum weigh about the same per cubic foot, the greater taper in gum bolts means less wood volume per cord, a reduction only partly compensated for by the larger average size of gum bolts.

The truck averaged 24 m.p.h. round-trip speed, or 0.036 truck-hour per cord per round-trip mile on graded gravel and paved roads and 5.7 m.p.h. or 0.153 truck-hour per cord per round-trip mile on dirt and woods roads combined. Standby time for loading was 0.3 truck-hour per cord. At the siding, 0.3 truck-hour and 0.8 man-hour per cord were required to hand-transfer bolts to railcars.

The plots were cut during dry weather. When the bottoms soften and water lies on the ground, bunching, loading, and other costs are much higher. The men wade in to fell trees, and skid rather than bunch the boles. The skidding distance is determined by the closest ground that will support a truck carrying about 1 cord of pulpwood. This truck is then driven to the nearest firm ground trafficable for a capacity load.

THE WOODYARD

The paper industry, concerned with improving labor productivity and making pulpwooding a better occupation, has in recent years developed the system of mechanized yards for coordinating wood deliveries to mills. Today about 300 such yards are in operation (7). Their chief but not their only virtue is that they relieve producers of the need to transfer bolts by hand, one at a time, from trucks to railroad cars.

The yards are usually located in favorable freight rate zones and stimulate a greater volume intake than is usual at public sidings. The increased volume comes from two sources: First, man- and truck-hours saved by professional producers are used to cut and haul more wood. The human energy conserved by the yard means more wood with less sweat. Second, wood cut by farmers and other part-time operators, especially lots too small to attract professional cutters, is now entering the pulpwood market.

While equipment varies in kind and capacity, the basic yard tool is a machine for hoisting bolts from the incoming trucks and placing them on rail cars. Hoists vary from light yardsters to heavy mobile cranes. Some of the yards have equipment for steel-strapping bolts into bundles for storage in the yard when cars are in short supply.

In this study, observations were taken at the mechanized yard at Canton. The yard has a mobile crane and steel-strapping equipment. It loads about 40,000 cords of pine and gum pulpwood annually from producers' trucks to railroad wood racks.

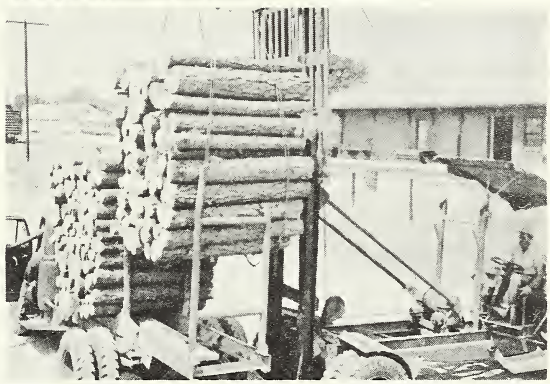
The Mississippi plots yielded about 440 cords of pine, of which 185 were man-handled a bolt at a time from the producer's trucks to

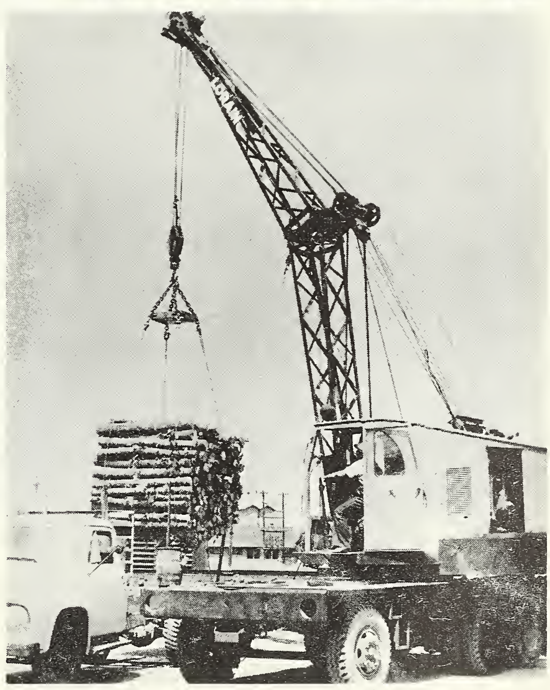
railroad wood racks at a public siding. The remainder were unloaded at the Canton yard. It took 0.6 man-hour per cord to transfer wood by hand.

Similarly, 270 cords of gum were studied. About 180 cords went to the yard and the rest to a public siding. Gum bolts required 0.8 man-hour per cord for hand transfer to wood racks.

To the unloading machine at the woodyard it made no difference whether the bolts were gum or pine. Tandems and bobtails were serviced at a cost to the producer of 0.1 man-hour per cord. This was the time expended by the driver in spotting the truck for scaling and machine transfer of bolts to the rail car. Turn-around time was 0.3 truck-hour per cord (either pine or gum) at the siding as against 0.1 at the yard. The data on operations at the Canton woodyard were substantially the same as those from the millyard at Camden, Arkansas.

Only the driver goes along with a load of bolts headed for a yard, while one or more men must accompany him to a public siding to help transfer bolts to cars. Thus for every man-hour expended in hauling to a yard at least twice as many are required for delivery to a public siding,





even apart from the actual task of unloading the bolts. The savings will vary with hauling distance. In general, the increased efficiency makes it feasible to haul farther to a woodyard than to a public siding.

Professional pulpwood cutters are not the only beneficiaries of woodyards. Because the yard will buy even small amounts of cordage, anyone, a farmer especially, now has a chance at the pulpwood market. Less-than-carload lots ordinarily find no buyers at public sidings, chiefly because wood dealers' margins do not provide much for the demurrage and scaling expenses that small-lot transactions tend to incur. After 48 hours railroads charge demurrage of $3 per day for four days and $6 per day thereafter to hold a car at a siding. The dealer finds it easier to work with professional cutters exclusively, not only because they fill a car in the allotted time but also because mill scale serves both parties in trading. None of these considerations apply to yards, where the wood is scaled on the spot, payment is expedited, and demurrage is no problem.

Figure 14.--Even small amounts of pulpwood are welcome at a woodyard.

In many respects the woodyard system has carried the millyard's functions and advantages out into the farthest reaches of pulpwood-producing territory. Thus it is a useful innovation for making pulpwood with less manpower. Additional innovations are needed to take more of the grunt and groan out of pulpwooding and make it a more attractive occupation.

THE PROBLEM

Busch (2) has pointed out that, until recently, getting pulpwood produced in the South was a simple matter of ordering more wood whenever the demand for paper products increased. Stumpage was cheap and the large pool of rural labor worked long hours at low wages. These factors were instrumental in expanding the South's paper mill output to 60 percent of the Nation's total.

In the meantime, the petrochemical, textile, aluminum, and many other industries discovered the South. Rural folk migrated to these plants as well as to paper mills, and many left the region. Wages rose and woods labor became scarce.

Despite many improvements in efficiency, pulpwooding manpower requirements are high. The typical small, lightly stocked woodland is still the chief source of stumpage. The average professional producer hires between 5 and 10 men and probably gets out less than 1,000 cords annually. Some mills using only 300,000 cords yearly deal with a thousand producing units (1).

The number of professional producers extant and prospects for increasing them do not appear to justify the expenditures required to engineer highly specialized equipment. The producer would like a machine that would sell for practically nothing, so that the woods worker could afford to buy it; would require practically no maintenance, run at negligible cost, and be operable by inexperienced men. Equipment manufacturers can make a living by solving simpler problems. The pulp and paper industry has met some of its wood-procurement difficulties by aiding forest managers to grow more and better timber, participating in development of pulp chips from heavy sawmill residues, and by originating the woodyard system. And the industry must still remain the chief source of innovations.

SOME ALTERNATIVES

Fundamentally, the industry's problems will be solved not by one heroic alternative but by numerous improvements designed to fit specific conditions.

Pulpwood producers can be conveniently divided into three groups. The first group includes chiefly farmers interested in cutting only a few cords each year, either from their own woodlands or from their neighbors'. A second group would include producers who can make a good living by operating yearlong with a 2- or 3-man team and the usual light truck and power saw. The third group, which is probably destined to be the mainstay of the industry, are the well-equipped producers operating 5- to 10-man crews.

The first group could be materially encouraged by some sort of pick-up and delivery system for bolts. That is, a palletized trailer could deliver empty pallets to the farmstead and call back when they were filled. This would allow farmers to use their own saw and tractor or mule.

The small full-time producers could be aided by clinics on the care and maintenance of power saws and the construction and use of inexpensive power take-offs and simple pipe-stanchion loaders for heavy bolts. To increase the number of large producers, it should be possible to help able members of this group expand their operations.

For the professional producers who can run a big operation, the horizons are much less limited. And it is in special reference to this group that growers, producers, and consumers of pulpwood share in the problem of pulpwooding with less manpower. One of the keys to maintaining the competitive position of the paper industry is having an increasing proportion of pulpwood cut by professional and well-equipped yearlong operators.

The difficulty of procuring stumpage limits the number of large producers, and cuts down the output of those already in business. The industry's conservation foresters are of considerable help in this matter, not only by encouraging landowners to grow more timber, but also in promoting partial cuttings where needed. Both services need to be greatly expanded. Because tracts and volumes in partial cuts tend to be small, the pulpwood cutter benefits when the forester can schedule his work so as to mark a number of tracts within a reasonable working area.

This study, in common with others, demonstrates that silvicultural requirements are compatible with the need of pulpwood producers for a reasonable cut per acre. That is, the ordinary periodic cuts of 3 to 5 cords per acre involved in managing reasonably full stands do not seriously impair labor productivity. But when foresters find it necessary to mark as little as one cord or less per acre they should offer such cuts to part-time producers rather than impose them on professionals. In modifying marking practices to serve professional producers,forest managers will be serving their own interests in the pulpwood market.

Buying pulpwood by weight could improve current as well as future productivity. Not only would human judgment involved in scaling be virtually eliminated but the time required of both buyer and seller would be shortened. A greater volume of wood could be handled by fewer people in yards and at the mills. Buying by weight would also encourage prompt delivery of green wood to the mill, which is advantageous from the standpoint of pulping and the avoidance of fiber loss from insects and decay.

Because it tends to take into account differences in wood density and in the content of the rough cord, weight is a better index of fiber yield than volume is. Too, buying by weight would reward the forest manager for growing older and denser wood, which requires fewer cords per ton of pulp.

Even under ideal conditions, producers still face the task of effectively mechanizing the job of picking up bolts in the woods and getting them on a truckbed. The development of light loading equipment should be considered. As a long-run proposition, changing the bolt length to about 10-1/2 feet might make machine development much more feasible than with 5-foot bolts. A longer bolt, of course, would involve adjustments all along the line from the woods to the chipper at the mill. To the extent that increasing acreages are handled on pulpwood rotations, managed clear-cutting will become more common, and mechanization will be easier than for partial cuttings.

Pending other solutions, pallets appear adaptable to more cutting conditions than they are now applied to. In hills and broken terrain boles might be bunched with light tractors and then bucked and loaded on pallets. It would of course have to be demonstrated that such a combination of the better features of flatwoods and hill methods is feasible.

The industry's improvements in paper chemistry and mill engineering over the years have reduced relative processing costs per ton

of pulp. In contrast, relative costs of procuring wood have risen steadily. The same positive thinking that is being applied to paper making needs to be directed to the possibilities of pulpwooding with less manpower. If it is, the cutters of tomorrow will look like men from Mars to those of today.

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